Annex E - Fire Resistance Test

General

In order to assist in the development of an appropriate fire resistance test for assessing the performance of cavity barrier systems, four typical cavity closure systems were subjected to an adhoc fire resistance scenario based upon a standard fire performance temperature-time curve using a 1.5m adhoc test furnace, see Photograph E1. The scenario adopted was designed to consider the influence of installation details on the performance of the systems when tested to the adhoc scenario and to therefore provide a practical approach to assessing these types of systems whilst recognising the need for a standardised test method.

Barriers

Four commercially available systems were selected for this investigation:

- Test 1 - Foil faced stone mineral wool, Photograph E2
- Test 2 - Plastic coated stone mineral wool, Photograph E5
- Test 3 - Extruded PVCU cavity closure, Photograph E8
- Test 4 – PVCU coated stone mineral wool cavity closure, Photograph E11

Experimental Test Facility

Test Frame

The test frame consist of a 1.8 m square steel frame in filled with a single skin block work wall incorporating 4 off 800mmx 55mm gaps running horizontally and vertically to represent openings in a block work wall, see Photograph E1.

Instrumentation

Each system was instrumented with chromel/alumel thermocouples, soldered to a copper disk and covered with an insulating pad. These were installed on to the unexposed face of the barrier systems to monitor local temperatures during the test. The thermocouple arrays for each test are shown in Figures E1 and E2 and Photographs E3,E6,E9 and E12.

Installation and Testing of Test Specimens

Each barrier system was installed into the three configurations provided in the test frame, see Photograph E1.

The test frames were then located in front of the adhoc furnace and subjected to a nominal 45 minute exposure to the temperature-time scenario or until such time as the integrity of the test specimen precluded the test continuing, see Photographs E4,E7,E10 and E13.

Failure Criteria

Since no method of assessing performance criteria for failure under integrity and insulation of these systems exist, those used for partitions, in BS 476 part 20 have been adopted as a basis of analysis for this work.

Integrity: Failure is deemed to occur:

a) when sustained flaming for not less than 10s on the unexposed face occurs:

b) when (before the exposed face in the vicinity indicates a temperature of 300°C) cracks, gaps or fissures allow flames or hot gases to cause flaming or glowing of a cotton fibre pad;

c) when, after use of the cotton pad has been discontinued, a 6mm-diameter gap gauge can penetrate over a distance of at least 150mm, or a 25mm-diameter gap gauge can penetrate through a gap into the furnace.

Insulation: Failure is deemed to occur:

a) When the mean unexposed face temperature increases by more than 140°C above its initial value;

b) when the temperature recorded at any position on the unexposed face is in excess of 180°C above the initial mean unexposed face temperature;

c) when integrity failure occurs.

Results

Tables E1 to E4 below summarise the observations from each of the systems tested. Graphs E1(a) to E4(c) show the temperature-time profiles determined for each of the systems tested.

Table E1 Visual observations from Test 1

Time	Observations
02:15	White smoke leaking from top of L cavity
02:54	Larger quantities of smoke noted at same location above
09:20	Smoke leaking along top vertical cavity
09:57	Smoke leakage from LHS of horizontal section L cavity
10:45	Smoke leakage from top of horizontal cavity
43:00	Glowing observed in top corner of L cavity

Table E2 Visual observations from Test 2

Time	Observations
01:11	Red plastic covering burning
01:25	Smoke leaking from single horizontal element. Left hand corner
01:58	Smoke leaking from along top of horizontal double element
02:35	Smoke production increasing
03:00	Smoke leaking from entire horizontal section
03:40	Smoke leaking from top of vertical element
04:05	Smoke from bottom of vertical part of double element
04:55	Gap developed in top of vertical element
05:30	Delamination of plastic covering along horizontal element
06:05	Delamination of plastic covering at top of vertical element. Cotton wool singed.
07:15	Deteriation of plastic 200mm down vertical part of double element
08:00	80% deteriation of plastic cover in horizontal element
08:35	Cotton wool singed at top of vertical element
09:25	Gap about 200mm developed in vertical element
10:25	100mm gap at side of double element. Cotton wool ignited when applied to gap
12:00	Glowing in top of vertical element. Cotton wool glowed when inserted in gap.
12:45	Noticeable drop in smoke production overall
13:20	90% of double element delaminated
15:15	Increase in smoke production overall
15:50	Cotton wool singed in right hand corner of double element
17:00	Cotton wool ignited in right hand corner of double element
19:45	Cotton wool did not ignite on horizontal element when placed in gap
20:00	Top horizontal element centre gap 400mm from LHS wool ignited
22:30	About 150mm gap half way down RHS of vertical element. No ignition of cotton wool
30:30	Test terminated

Table E3 Visual observations from Test 3

Time	Observations
01:25	Smoke leakage RHC from horizontal section of double element
02:45	Smoke leakage from top of vertical element
03:15	Smoke leakage from bottom of vertical element
03:40	Smoke leakage from bottom of vertical double element Gap open at LHS of horizontal double element
04:30	Smoke leakage from horizontal element – thick smoke
05:00	200mm gap in LHS of horizontal section of the double element Smoke very thick from all elements
05:15	Cotton wool singed when inserted in above gap
05:30	Gap exceeded 6 x 150mm on LHS of horizontal double element Failed on gap criteria
06:30	Major glowing on unexposed side in above element
07:30	Smoke production dropped. Flaming from vertical element including vertical of double element
08:10	No flaming from horizontal element
08:55	Cotton wool singed in lower half of vertical element
09:10	Smoke production increased - very thick
10:00	Additional fire stopping material inserted into horizontal section of double element
10:20	Horizontal element glowing
10:30	All three elements failed
11:20	Photos taken - pale blue smoke from all elements
14:00	Flaming from two horizontal sections
18:00	Test Terminated

Table E4 Visual observations from Test 4

Time	Observations
01:50	Smoke from centre of horizontal element
02:05	Smoke from centre left of horizontal double element
02:23	Smoke from the top of vertical element
02:51	Smoke becoming thicker from both horizontal elements
03:07	Smoke from bottom of vertical double element
04:30	Smoke from bottom of both verticals
04:50	Deformation of plastic backing on vertical double element
05:34	Thick smoke from centre of horizontal element
06:25	Thick smoke from centre of vertical element
07:40	Plastic backing to vertical element bowing out wards
08:20	150 mm gap in horizontal double element LHS
09:10	Cotton wool applied to above gap. No ignition.
09:30	Cotton wool applied 150 mm from LHS on Horizontal element. No ignition
10:45	Gap in horizontal section 150mm from RHS of double element. No ignition of cotton wool.
11:45	Gap along centre of Horizontal element and in corner (25mm) of double element
12:15	Cotton wool pad applied to centre LHS of horizontal element. No ignition.
13:30	Plastic backing on double element has distorted significantly. RHS backing has dropped to floor. Glowing on both sides.
13:40	Gap in LHS of Horizontal element.
14:10	Application of cotton wool to horizontal left hand edge. No ignition.
15:15	Glowing in left hand lower edge glowing of Horizontal element.
15:45	Ignition of cotton wool when applied to LHS bottom edge of Horizontal element
17:18	Application of cotton wool to top of vertical element. Singed only - no ignition.
17:45	Gap exceeded 6 x 150 mm in Horizontal section of double element
20:30	Double element horizontal section has gaps along top edge a third long on both sides
	Horizontal element has a gap along entire length of the bottom edge
21:00	Gap in top LHS of vertical element extending down by 200mm
21:40	Application of cotton wool to top of vertical element. Cotton wool pad ignited
26:00	Confirmation of Horizontal element failed on gap criteria
29:00	Vertical section of double element failed on gap criteria (LHS)
30:44	Gap in Vertical element has not exceeded gap criteria.
33:00	Confirmation that all plastic backing has gone.
35:00	Test Terminated

Table E5 summarises each of the system performances based on the performance criteria set out above.

Table E5. Summary of Performance based on failure criteria set in BS 476: Part 22.

Test	Vertical element		Horizontal element		Double element	
	Insulation	Integrity	Insulation	Integrity	Insulation	Integrity
Test 1	Failure Criteria not met during exposure	Failure Criteria not met during exposure	Failure Criteria not met during exposure	Failure Criteria not met during exposure	38 mins	Failure Criteria not met during exposure
Test 2	11.5 mins	12 mins	7 mins	20 mins	5.5 mins	10 mins
Test 3	7.5 mins See note (1)	7.5 mins	7.5 mins	10.5 mins	5 mins See note (1)	5 mins
Test 4	11 mins	21.5 mins	9 mins	15.5mins	11 mins	17.5 mins

Note. (1) – Where the element has failed on integrity it is also considered to have failed on insulation.

These tests where carried out as part of a research project on an adhoc furnace. The results cannot therefore be used as replacement for tests carried out in standard fire resistance furnaces or be used as a demonstration of performance in practise.

Discussion and Recommendations

Based on the visual observations and thermal responses monitored during this work, see Graphs E1(a) to E4(c), the temperature time curves used to assess the performance of these systems is unlikely to be the key parameter effecting the overall performance of the systems. The fire performance of the systems appears to be related, primarily to the installation and stability of the system once installed within the cavity, the corner detail appears to be a particularly vulnerable design detail, see Photographs E 6 and 7. This may be due in part to the ability to form a tightly fitting material interface with some of the systems tested.

This raises issues regarding performance in service in relation to the ease of installation and hence associated workmanship related to the ‘end use’ of the system. It therefore appears to be a critical element in the design and specification of these systems to ensure that the ‘end use’ application is clearly defined and that the systems are used only those situations for which they are designed.

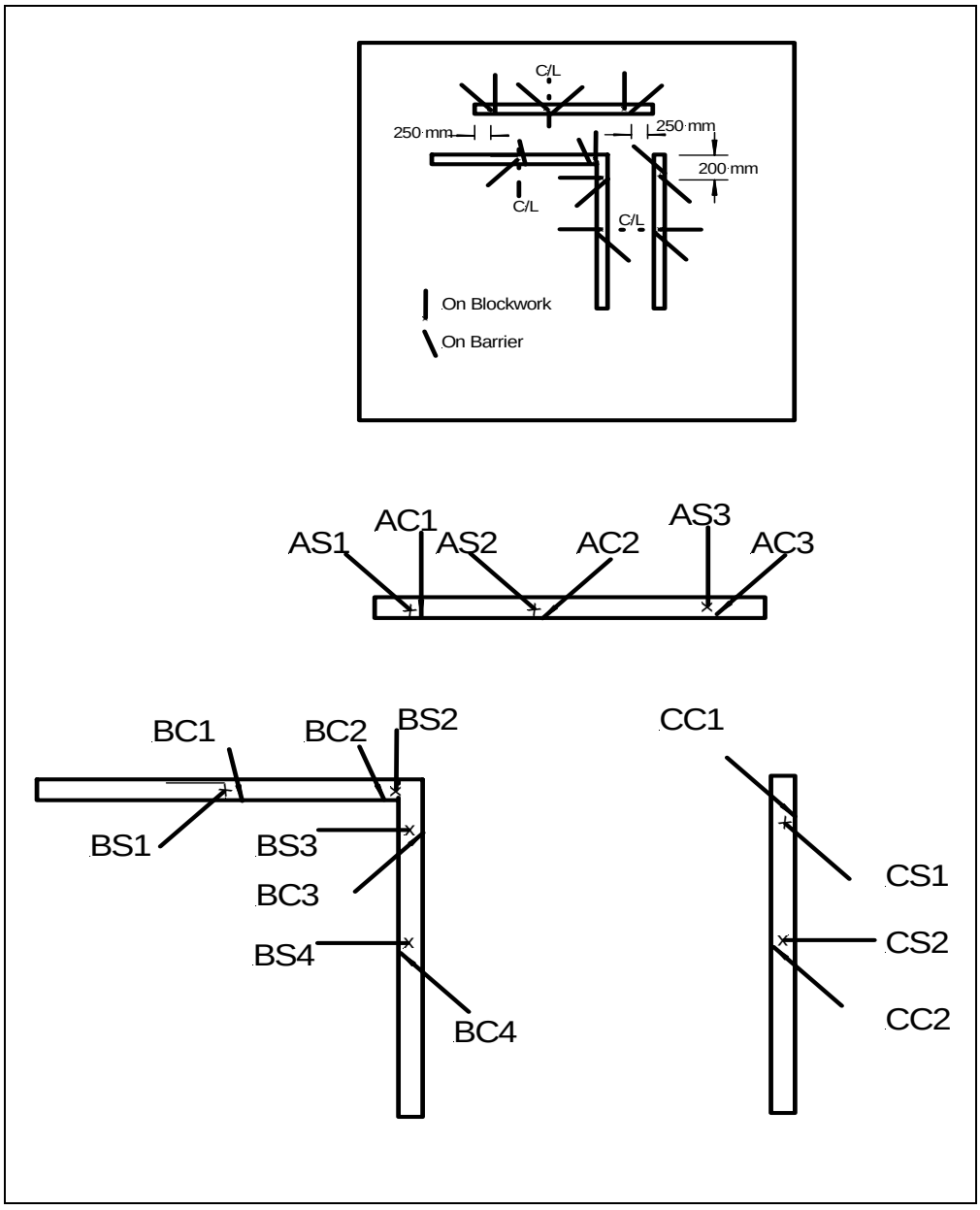


Figure E1. Thermocouple array used for Tests 1, 2 and 3.

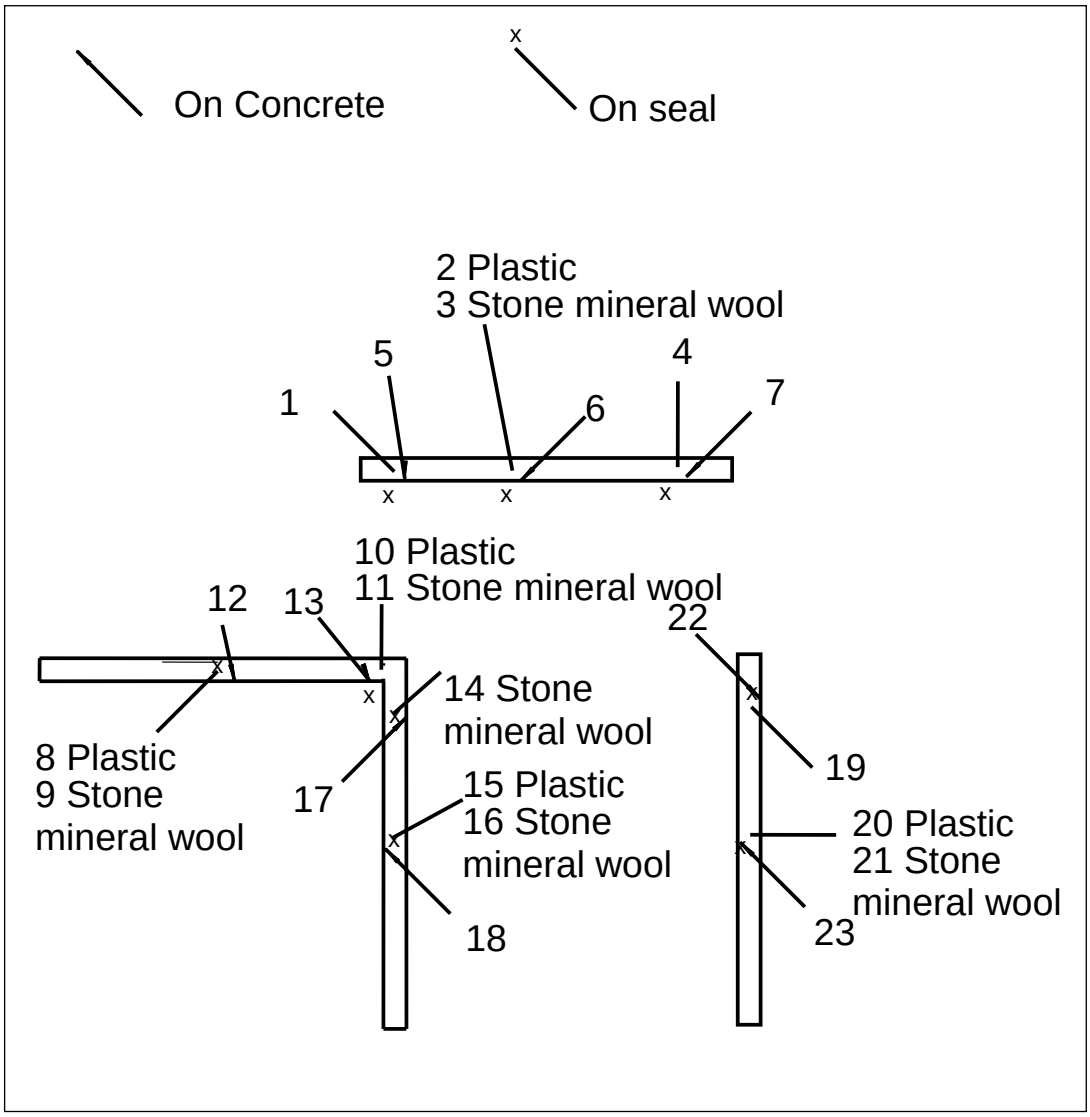
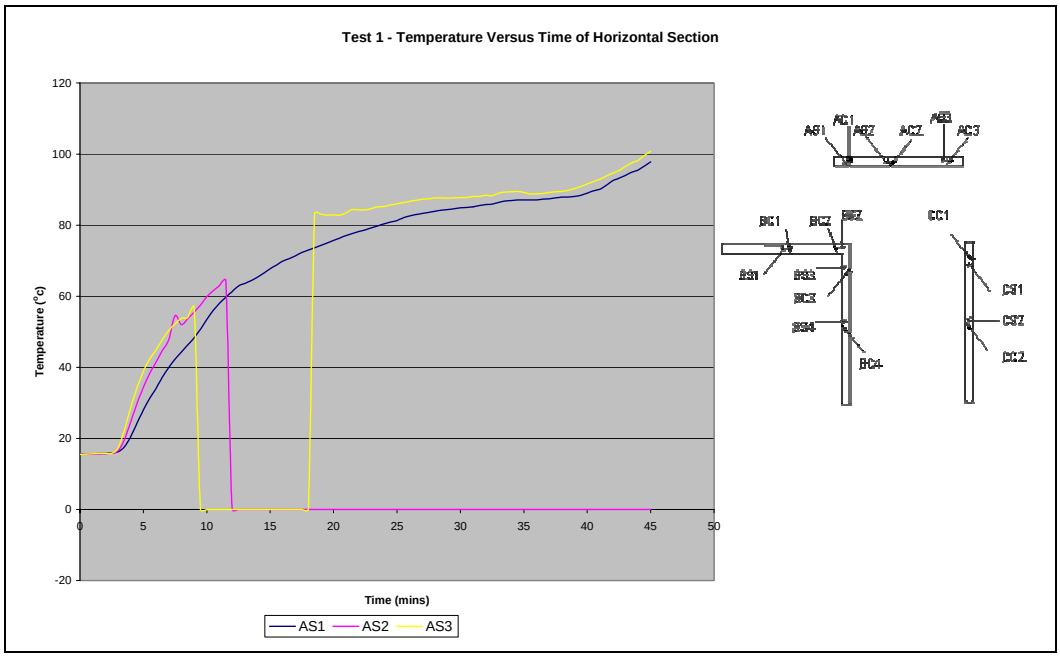


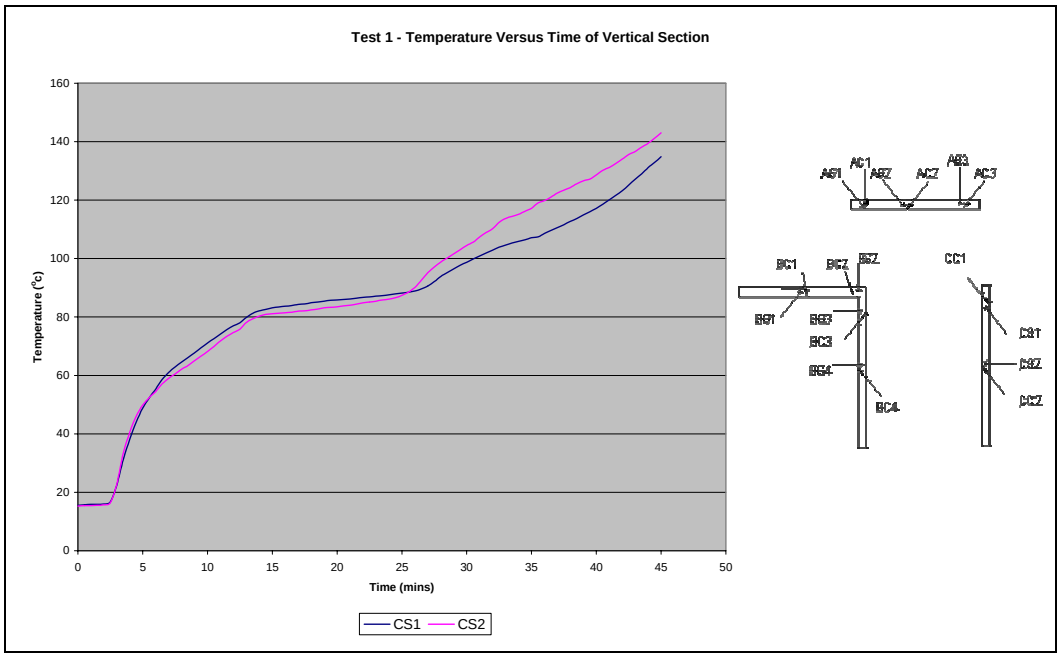
Figure E2. Thermocouple array used in Test 4.

Temperature time curves for Tests 1 to 4.

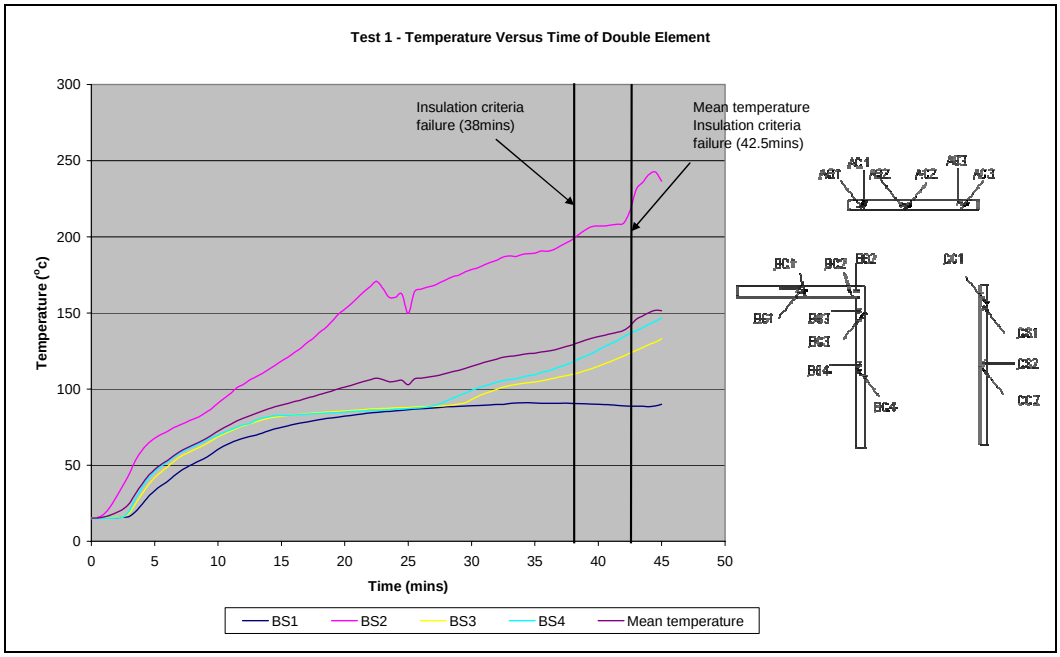
Test 1



Graph E1a. Horizontal section

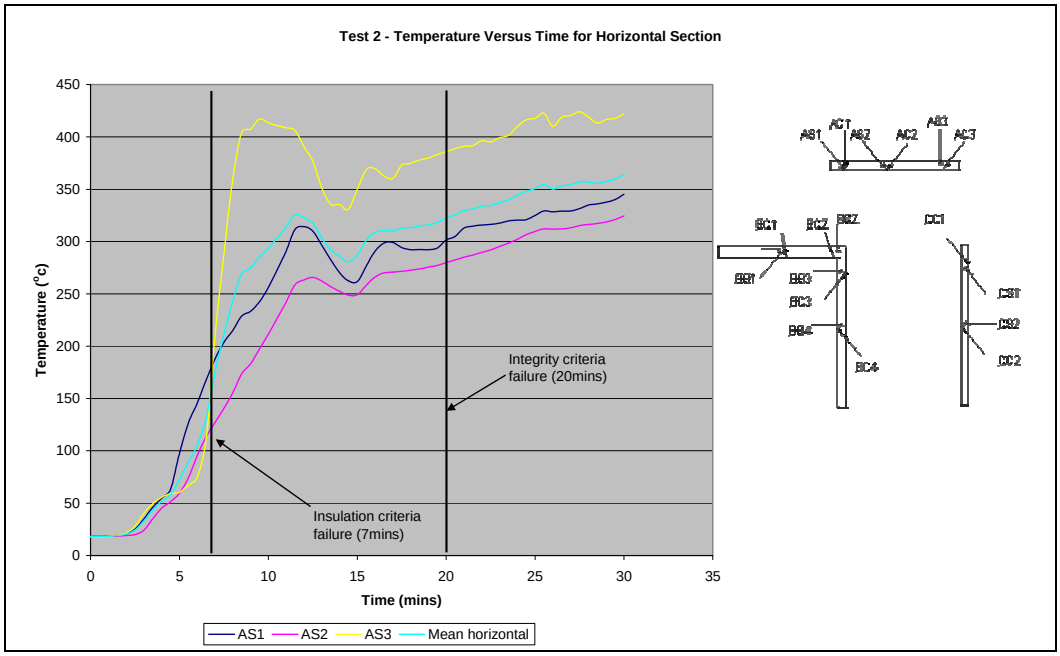


Graph E1b. Vertical section

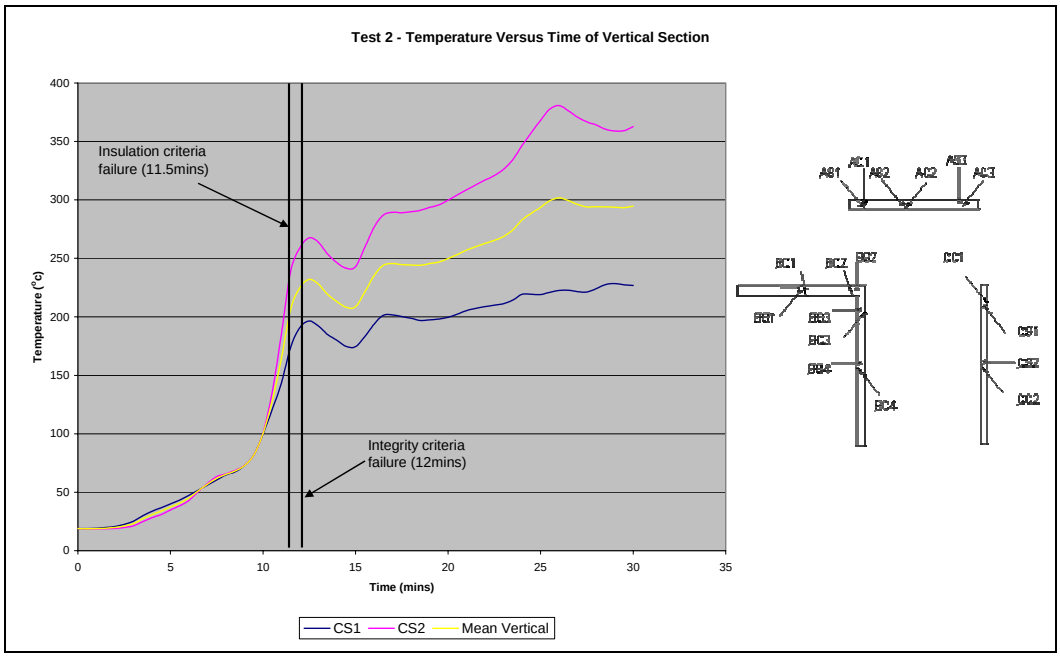


Graph E1c. Double element

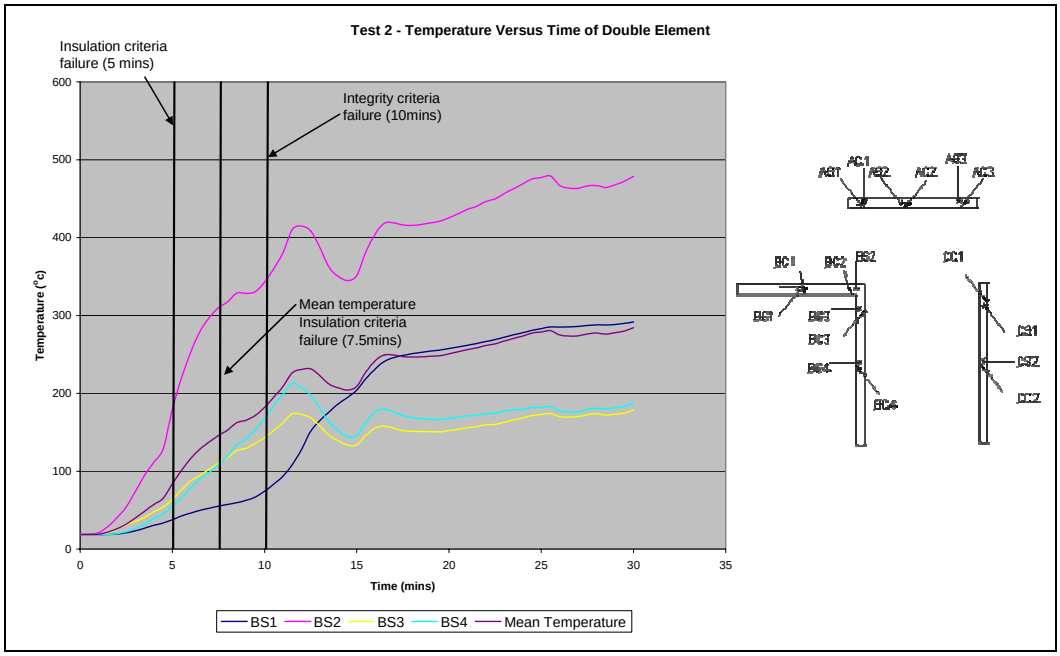
Test 2



Graph E2a. Horizontal section

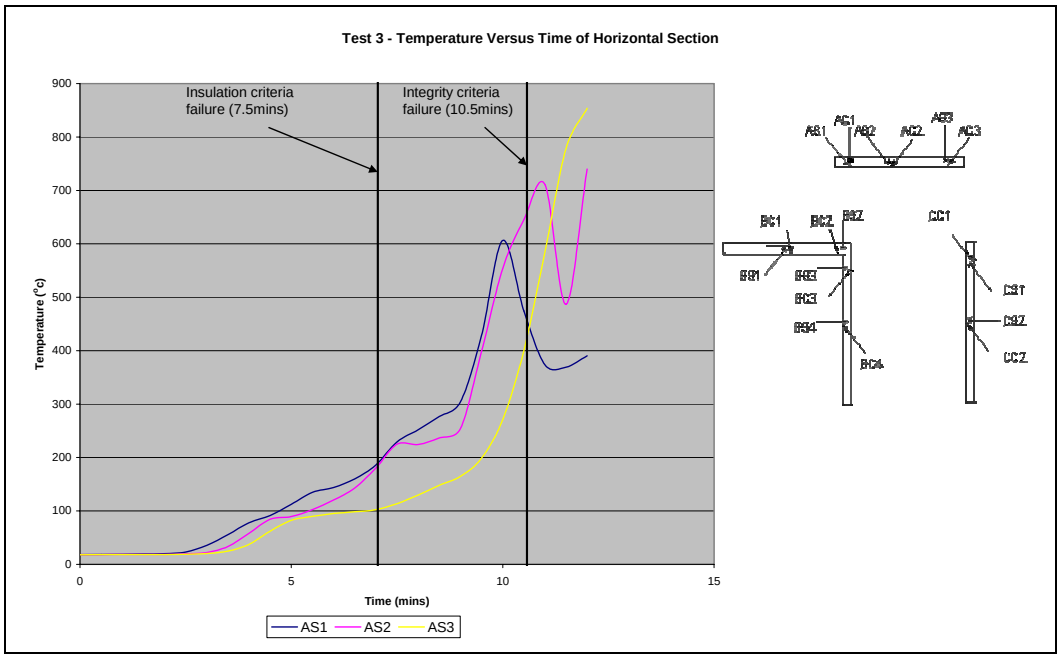


Graph E2b. Vertical section

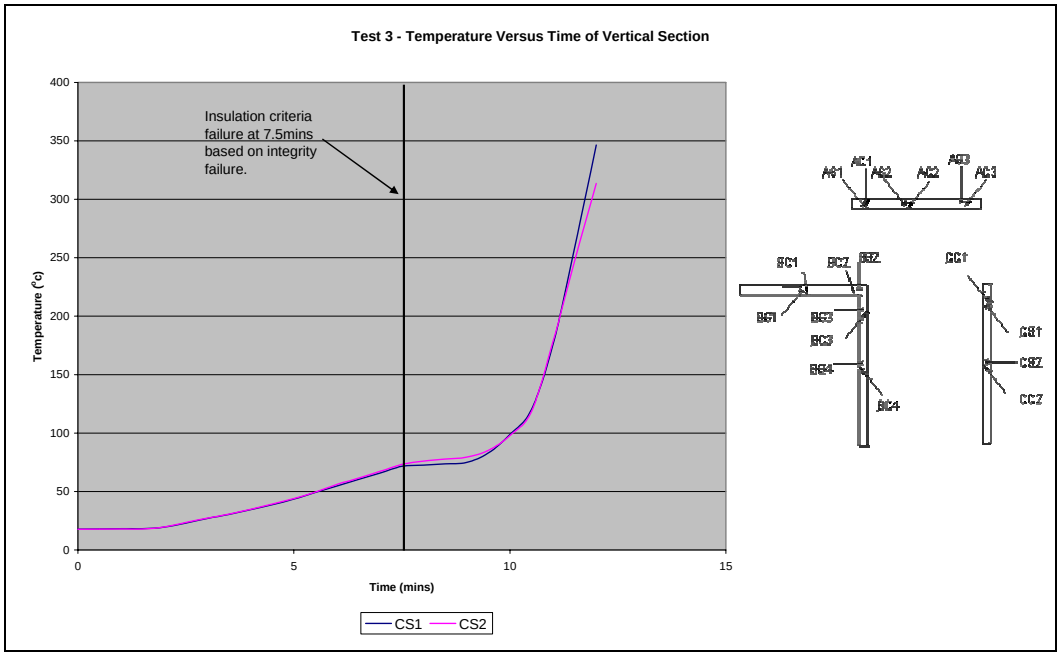


Graph E2c. Double element

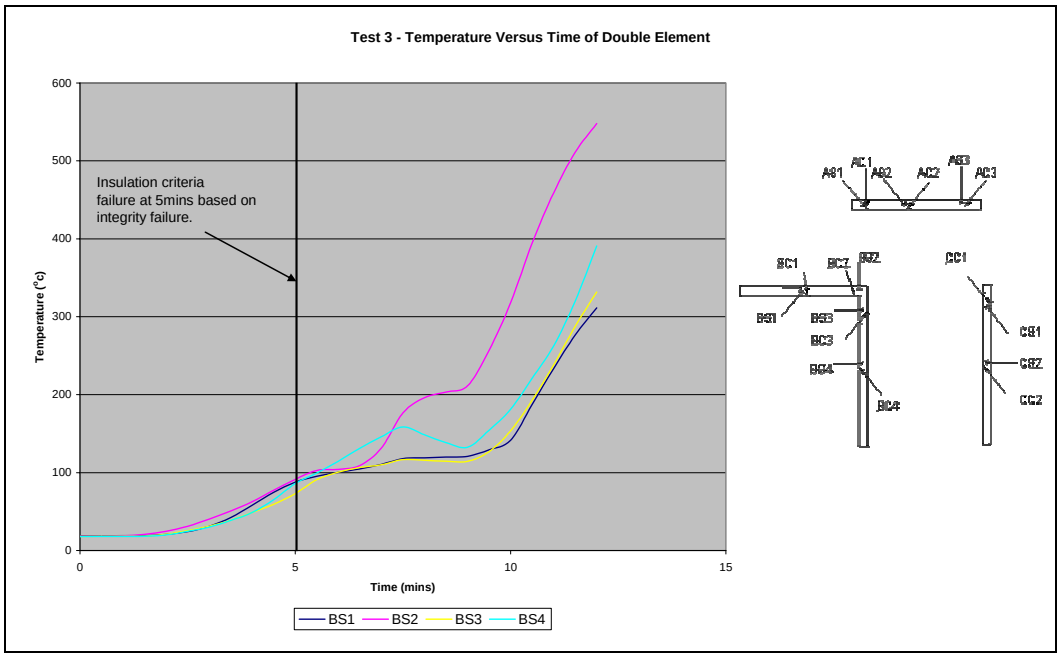
Test 3



Graph E3a. Horizontal section

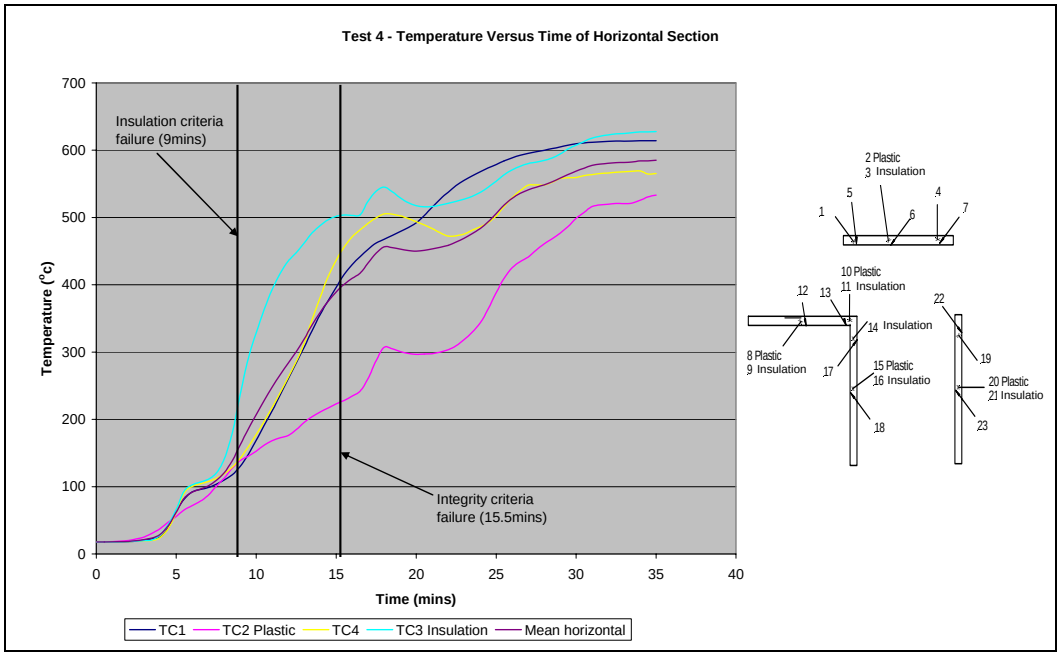


Graph E3b. Vertical section

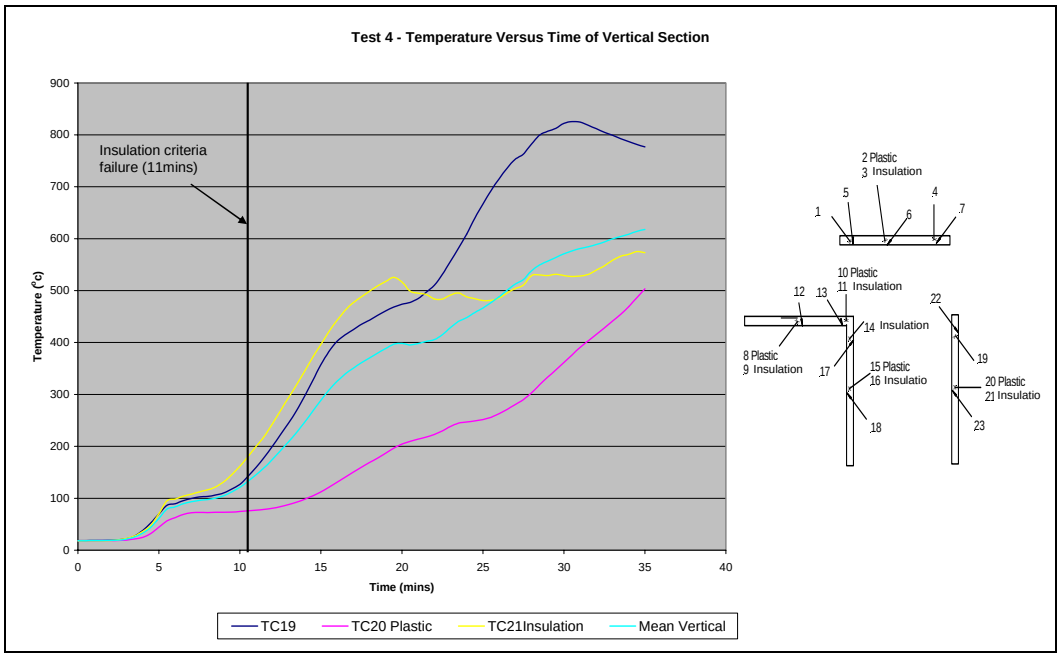


Graph E3c. Double element

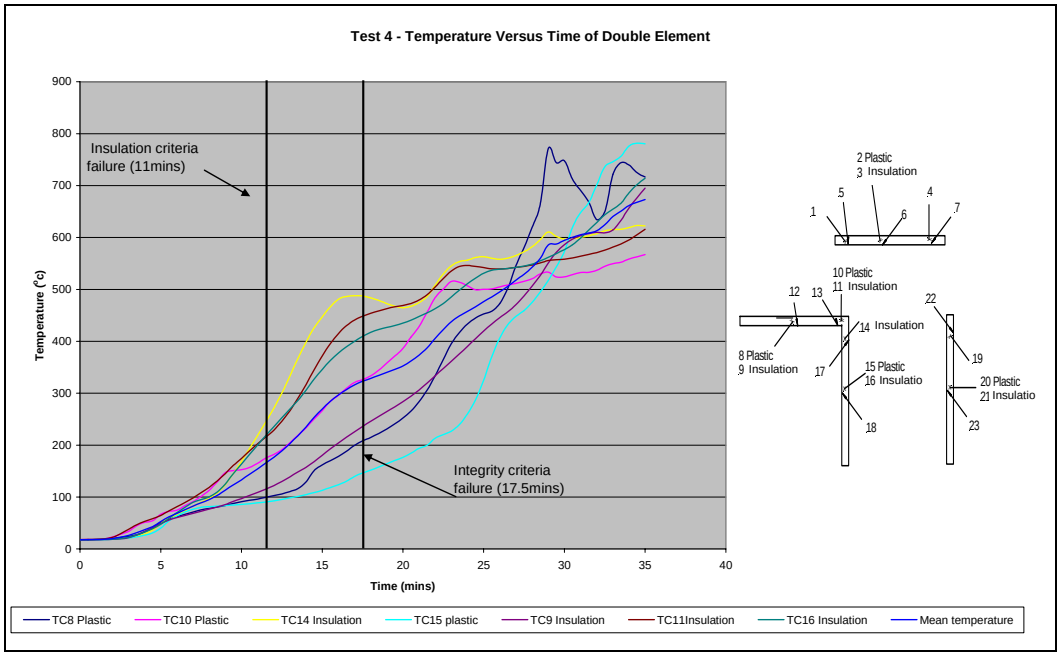
Test 4



Graph E4a. Horizontal section



Graph E4b. Vertical section



Graph E4c. Double element.

Photographs.

Photograph E1. Layout of the test rig

Test 1

Photograph E2. Test 1 material

Photograph E3. Material for Test 1 installed in the test rig

Photograph E4. Instrumented test piece

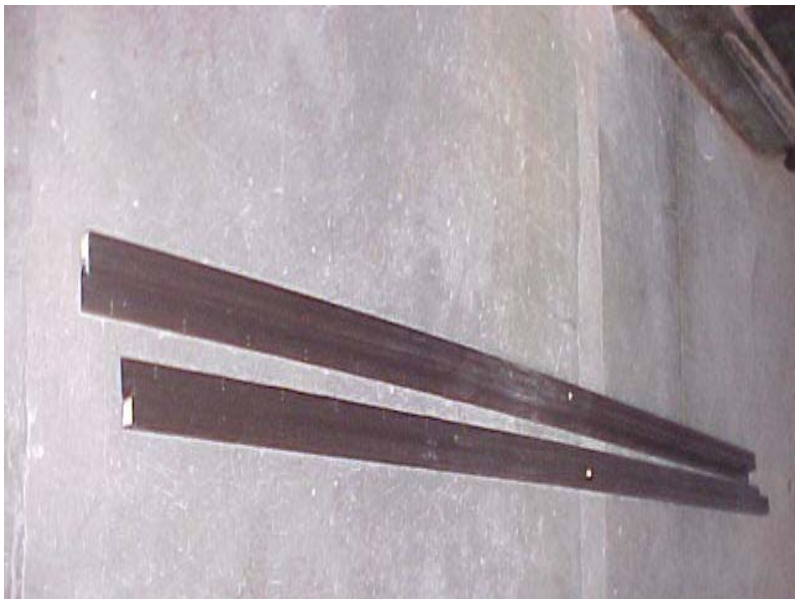
Test 2

Photograph E5. Test 2 material

Photograph E6. Material installed in test frame

Photograph E7. Material during test

Test 3

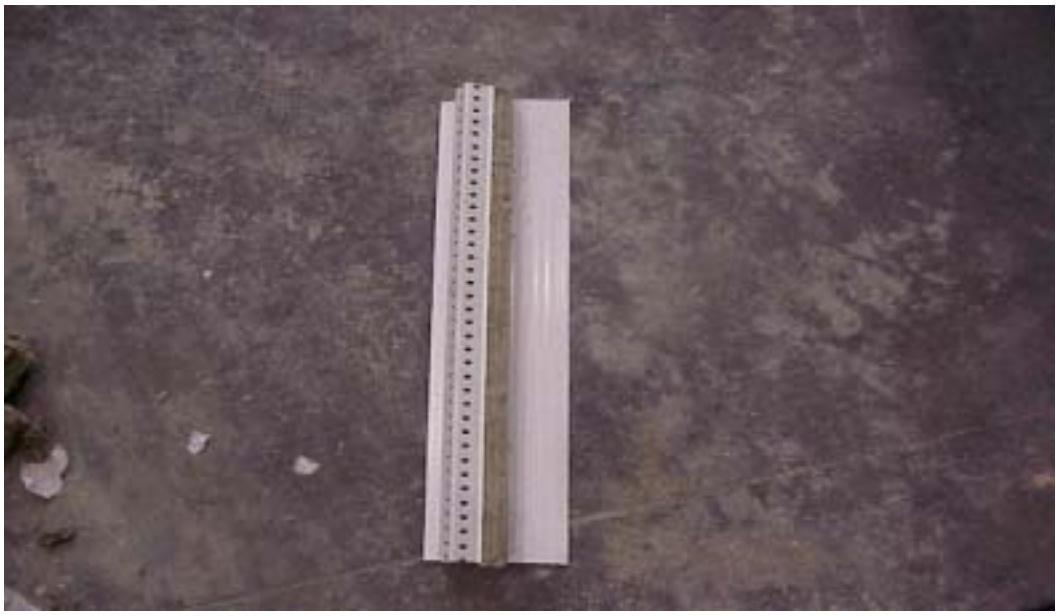


Photograph E8. Cavity barrier material

Photograph E9. Material installed in the test frame

Photograph E10. Material during the test

Test 4



Photograph E11. Cavity barrier material

Photograph E12. Material in the test rig

Photograph E13. Material during the test